THE ETIOLOGICAL IMPORTANCE OF ABNORMAL FOOT POSTURE IN AFFECTIONS OF THE KNEE.[1]

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IN all ages builders have realized the importance of a secure foundation, and the "man which built his house upon the sand" has been justly held up to ridicule. In the human frame the foot is essentially the foundation of the body, and mechanical principles are similarly involved, although modified, it is true, by the adaptability of the muscular system. When, however, muscular control weakens, the natural and acquired errors in the structure become apparent and produce symptoms which are easily understood, if viewed in the light of mechanical laws.

Despite the great amount which has been written about the weak foot, few, if any, of the ills to which flesh is heir are more poorly treated; and such will continue to be the case as long as it is deemed sufficient to send the sufferer to the instrument maker for "a pair of plates." To him who aims at the cure of the affection by the restoration of normal function, the available literature furnishes all that is necessary. One of the more remote effects of the weak foot, however, while mentioned by various writers, has not in my opinion received the emphasis which it merits. Through the abnormal position of the foot an excessive strain is thrown upon the knee and its muscles, which may not only give rise to pain in and around the joint, but, if unrelieved, may also produce actual joint changes; further, strain due to such abnormal foot posture may be a very potent factor in keeping up disability of the knee-joint due primarily to other causes.

The references in the literature to this phase of the subject are practically limited to a few works on orthopedic surgery and to several special articles.

In speaking of the more or less unusual symptoms of flat foot, Bradford and Lovett mention the occurrence of pain and a feeling of strain at the insertion of the hamstring tendons, pain and irritability of the knee with, in some cases, recurring attacks of synovitis, and occasionally backache. Whitman states that there may be "pain in the knee, hip, or lumbar region, symptoms more common in women than in men." Dane, in an excellent paper on the mechanics of the subject, definitely locates various points of pain above the ankle, and Stone also refers to them. In an analysis of 1000 cases of static foot trouble, Blodgett noted pain in the knee in 73 cases; in 21 cases the pain was wholly above the ankle, and of these, "13, or more than half, had pain only in the knee, usually over the internal condyle, and 4 others had pain in the knee associated with pain elsewhere above the ankle;" he calls attention to the fact, moreover, that knee symptoms are more common than his analysis would indicate, since cases of villous arthritis, due to flat or pronated feet, were not included in his series. In view of these statements, it is rather surprising to find no mention of pain above the ankle in several of the recent American and German orthopœdic text-books.

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As regards the production of definite joint changes, Goldthwait says that chronic villous arthritis of the knee "is very commonly associated with, and is undoubtedly in part due to, flat foot, the weakness here having resulted in strain and weakness at the knee." In the same connection Painter and Erving state: "Flat and pronated feet, by causing strain to the internal lateral ligaments of the knee, are common causes of congested and hyperemic knees, particularly in stout and flabby individuals, usually women."

The value of a corrected foot posture in recurrent dislocation of the internal semilunar cartilage is recognized by Robert Jones and by Lovett, but I have failed to find any reference to its value in other affections.

When studied from the mechanical standpoint, the reasons for the production of symptoms at the knee by a weak foot are clear and distinct. Such symptoms are due indirectly to the inherent instability of the knee and directly to: (1) Strain exerted laterally on the internal lateral ligament, and (2) strain due to interference with the normal rotation of the femur on the tibia; their time of appearance and severity are dependent upon the muscular control.

INHERENT INSTABILITY OF THE KNEE.—"The knee is a joint depending entirely upon the ligaments for its strength. Disregarding the patella, there are only two small articular areas in contact in all positions of the limb. . . . There is neither cup nor socket nor real concavity of any sort. . . . The two bones with the articular cartilages left on and all the ligaments removed are in unstable equilibrium in all positions. This mechanical disadvantage and the arrangement of the lubricating apparatus, which is at times inadequate and at times an absolute obstacle to the working of the joint, furnish the chief reasons why the knee is the most frequently deranged of all the joints in the human body" (Tenney).

LATERAL STRAIN. There are normally a few degrees of divergence of the thighs, and this is more marked in women than in men on account of the greater width of the pelvis; as Lovett expresses it, "Some degree of knock-knee is anatomic." This necessarily produces a slightly greater strain upon the structures on the inner side of the knee. The assumption of the so-called "attitude of rest," in which the feet are separated and everted, increases this strain in proportion to the degree of pronation (rolling in of the ankle) which occurs. It is further increased in walking with the legs in outward rotation, since in this position the line of motion of the knee-joints diverges from that of the body. That the force thus exerted upon the internal structures of the knee is one to be reckoned with, is evident, since it is sufficient in susceptible individuals to produce the deformity of knock-knee, to which, in some cases, at least, flat foot stands in causal relation, and the correction of which in the milder degrees is possible by throwing the weight on the outer edge of the foot.

INTERFERENCE WITH NORMAL ROTATION OF THE FEMUR ON THE TIBIA. The axis of the ankle-joint is directed slightly downward and backward; in the normal foot, according to Dane, the two axes meet in the horizontal plane in an angle open backward of 169 degrees and in the vertical plane in an angle open downward of 154 degrees. This divergence is of undoubted assistance in maintaining the upright position with a minimum of muscular effort. At the knee the final act of extension consists in a gliding backward of the larger, inner condyle, so that the femur is rotated inward on the tibia; similarly, the beginning of flexion is accompanied by a rotation outward of the femur (Quain); this aids in maintaining the knee in extension. Into the mechanism at the hip it is not now necessary to go.

In the assumption of the weak- or flat-footed position, the foot moves inward and downward at the mediotarsal joint, while the heel and the ball remain fixed. This has two effects: (1) The divergence of the axes of the ankle-joints is diminished, and the assistance thereby afforded in the maintenance of the upright position is decreased or lost; and (2) the tibia, which participates in the movement, rotates inward, thus "interfering to a great extent with the operation of the mechanism by which complete extension of the knee should lock the joint and render it proof against the constant tendency of the body weight to flex it" (Dane), thus necessitating the constant exercise of muscular force.

MUSCULAR SUPPORT. Normal muscular tone is the prerequisite of a normal posture and a normal gait, and as long as it exists, mechanical defects of a considerable degree may be present without producing symptoms. With diminishing muscular power, the individual tends to assume a posture in which more and more weight is transferred to the ligaments, and under such circumstances slight deviations from the normal become active. Hence it happens that the conditions under discussion are seen in children who have grown rapidly, in the weak and debilitated from any cause, and in the abnormally stout.

As an example cf the subject, one may picture the amount of traumatism (to the knees) sustained during the afternoon's shopping expedition of a short, very stout, and correspondingly flabby individual with pronated or flat feet, and wearing the conventional French heel, whose already too small base is more or less rounded by use; imagine for a moment the repeated injuries that occur from the standing before the counters, the walking over uneven streets, the clambering up and down the very high steps of our streets cars, and possibly the half hour's clinging to the strap while she is jerked this way and that with every movement of the car. With such a complicated joint as the knee the wonder is that any such escape.

Insistance must also be laid upon the fact that in the normal individual a knee which has been injured, either by traumatism or disease, is in exactly the same condition as if the individual were generally weakened. The relaxation of joint structures, which naturally follows inflammation, and the muscular atrophy from disuse render the joint more susceptible to injury. Under such circumstances, in an exactly similar manner, slight deviations from the normal foot posture may throw sufficient strain on the knee to retard or even prevent recovery. In such cases correction of the foot error may bring immediate improvement. It is my opinion that in all cases of primary knee-joint affections any apparent defect of the foot should be corrected, and that in cases of long standing, even in the absence of any apparent defect, the weight should at least be transferred to the outer side and the foot brought into the adducted position. If such details were more carefully carried out in the treatment of acute affections of the knee, it is safe to say that fewer chronic troubles would be seen.

The following cases are presented as examples of this condition; others might be cited, but these are sufficient to illustrate the various types:

CASE I.—Mrs. F. G., referred by Dr. James I. Johnston, was seen February 16, 1906. She had first noticed soreness in the right knee about a year and a half before, following extra exertion, and a few weeks after an attack of tonsillitis; two or three weeks later the left knee also became affected. Some puffiness about the joints and "grating" were noted; there was no pain any place else. No benefit had followed a rest in the country nor massage and salt baths at Atlantic City. She now complained of pain up and down the legs, chiefly in front. On account of her circumstances she was obliged to be on her feet a great deal, and was also under considerable nervous strain. The patient was a fleshy, middle-aged women in fair general condition. There was slight fulness on each side of the patella tendons and above the patellæ; no demonstrable fluid; no palpable fringes; slight crepitation; on the right knee there was tenderness over the internal lateral ligament. The feet were markedly everted in walking and there was marked pronation; double hallux valgus of moderate degree was present; the heels of the shoes were small and high.

The knees were supported by flannel bandages, and electricity and compresses were used. The shoes were changed so as to give a firm base of support and to correct the pronation, and the arches were supported. Improvement was gradual but steady, and when last seen, in May, the patient was quite comfortable.

CASE II.—Mrs. J. D. F., referred by Dr. James P. McKelvy, was first seen June 19, 1907. She had been troubled with stiffness of the knees, especially the left, for two or three years; pain had been absent until the last few weeks, and about a week ago became especially severe in the left knee; the knees were "puffed out on the sides" at night. She had noticed that she was worse when she sat a good deal or ran the machine. The stiffness was the especial complaint.

The results of examination in this case were similar to those in Case I, except that there was considerable swelling (synovial) of the left knee.

Treatment consisted of several weeks' fixation of the left knee in a splint, hot and cold douching, bandaging, etc., and the correction of the foot condition as in Case I. When last seen, in August 1907, the patient was in good condition.

Cases I and II represent the type of congested knees (in some cases going on to villous formation), which are seen in stout, flabby individuals, with flat or pronated feet.

CASE III.—J. S., a male, aged eight years, was referred by Dr. W. W. Jones on account of trouble with the right knee. He was first seen on December 18, 1905. About two years and a half ago, following kneeling on the wet ground, the right knee became swollen and painful, and he was in bed for about two weeks, although not especially inconvenienced. Fifteen months later there was a second attack of pain and swelling, and he was in bed again for a time. Within the last six months he has had trouble three times. His present trouble dates from three weeks ago, when he had a fall, and was supposed by the friends to have put the knee out of joint; several days before coming to see me he had struck it again, and had complained greatly of pain, although he had continued to use it. He had limped slightly for about a week.

The patient was a slender lad in not very good general condition. The right knee was a quarter inch less in circumference than the left (he had been wearing an elastic knee-cap), but the thigh and calf were a half inch larger. There was some spasm of the hamstring tendons. No apparent abnormality of the joint could be detected, except that there was a slight degree of relaxation of the ligaments. The feet were plainly weak, and there was noticable twitching of the muscles during standing; there was in-toe and considerable pronation.

Treatment consisted in support to the knee by a flannel bandage, the alternate hot and cold douche, correction of the abnormal foot posture by changes in the shoe, and later, when the spasm had disappeared, the use of exercises to build up the leg muscles. Up to

February, 1908, when last seen, the patient has experienced no further trouble.

CASE IV.—Miss A. G., aged seventeen years, consulted me May 29, 1906, in regard to pain in the right knee. About four years ago she had twisted the foot and hurt the knee, and since then had "hurt" it at various times, losing a day or two. Pain is referred to the outside of the knee, is dull in character, and lately has run up to the hip; there has also been some pain below the knee; no history of locking or grating; a little swelling has been noted at times.

Here also examination failed to reveal any abnormality in the knee, but the weakness of the feet was at once apparent when the patient walked across the room; the feet were markedly pronated and the toes showed the marks of compression by the improper shoes. Correction of the foot error by a proper shoe, the use of appropriate exercises, and instruction in walking gave immediate improvement, and when seen about a year later, the patient had experienced no further trouble.

CASE V.—S. S., male, aged eighteen years, consulted me October 20, 1907. About a year ago, without any known cause, he noticed swelling of the left knee around the patella, which disappeared under bandaging; there was no redness, no pain, and no interference with motion. He has continued to wear the bandage and the knee seems to be getting weaker. During the last few weeks there has been some pain on the inside of the knee, but no sudden sharp pain, no locking, and no interference with motion. He has noticed at times some stiffness in the arch of the foot, and has a tendency, which he cannot explain, to stand on the outer edge of the foot.

There was marked varicose veins on both legs. The left knee was slightly (not over a quarter inch) larger than the right; the calf was a half inch larger. There were no tender points about the knee and nothing to be felt, except crepitation in the joint. The left foot presented a marked degree of distortion during use, the mediotarsal joint being displaced inward and downward with each step.

The alternate hot and cold douche, a corrective heel, a Whitman arch support, and exercises were prescribed.

When seen ten days later, all discomfort in the knee had disappeared, and when last seen, in December, 1907, there had been no return.

Cases III, IV, and V are of especial interest because of the very early age at which knee symptoms appeared and the very prompt and permanent response to the correction of the static foot error. In these cases the condition was simply one of strain without the production of joint changes.

CASE VI.—R. H. W., referred by Dr. George Wright, was seen March 5, 1907. Five months before he had twisted the right knee through a fall; there was not much swelling or pain and no ecchymosis. A week later, ordinary measures having been used in the meantime, he returned to his home in Boston, where his family physician found effusion into the joint and applied a cast, following which the effusion disappeared in about two weeks; in addition to the fixation he had some massage. When he left Boston he was still limping and motion was limited. After a few months he could walk a mile without discomfort, but more brought on pain just to the inside of the patella, and in the calf and up the leg; there was also some pain in the heel. About two months ago he noticed crepitation. A bone-setter diagnosticated a dislocated tendon and replaced(?) it without apparent effect. He complains most of pain on the inside of the leg near the knee.

The patient was a muscular young adult with noticeable general looseness of the joints. There was considerable atrophy of the leg, but no demonstrable change in the joint; in standing, the right knee was not so fully extended as the left, which, indeed, was slightly recurved; the discomfort of which he complained was located definitely over the inside of the joint. Both feet were markedly pronated and everted, and there was a marked excursion downward and inward at the mediotarsal joint at each step; this postural defect had evidently been present for years.

The knee was treated in a similar manner to that in the previous cases, and the defect of the foot was corrected by changes in the shoe and by a felt pad under the arch. Improvement was soon apparent. Later, when he was going into the woods for a vacation, a steel arch support was made for him, with which he went through an active hunting and fishing trip without discomfort.

After resuming office work, however, there was a slight but persistent return of the discomfort. A course of massage brought up the size of the leg to about that of its fellow, but failed to relieve all the trouble. The patient then volunteered the information that he had less discomfort after walking a long distance than when engaged in less active exercise, as, for example, after billiards. Following out this suggestion, he was allowed to engage actively in walking and other sports, and when last heard of had walked five miles without inconvenience and had been dancing.

Case VI is of interest because of the two points which it illustrates. The static foot error had been present for years without producing symptoms until the resistance of the knee was lowered by injury; then it played a very definite part in preventing full recovery. The general looseness of the joints had also caused no inconvenience, no doubt on account of the excellent muscular development; with the lowering of the muscular tone from disuse, however, this looseness also became an active factor in retarding complete recovery.

CASE VII.—T. P. McD., an ironworker, consulted me September 6, 1907. Two months before he had been struck just above the left patella by a "reverse lever." The knee began to swell in a few hours, but there was no ecchymosis; he was in bed for about a week (but without a splint), and since then has used a cane. He now has most pain in the mornings and gets very tired toward evening; there is some swelling and what he describes as "a catching" below the knee; he complains a great deal of a twitching of the muscles on the front of the thigh; he can walk but a short distance and cannot go up steps.

The patient was a very muscular young adult, in excellent general condition. The left knee was very slightly swollen, chiefly in the region of the infrapetellar pad. The patella floated moderately. The point of tenderness complained of was just above the patella, where he had been struck. There was no apparent abnormality below the knee.

On account of the evidence of fluid in the joint, the knee was first baked and strapped with the adhesive strapping, but, as the strapping produced several large blisters, this was discontinued and the knee put on a splint; massage, electricity, and, later, alternate hot and cold douching were then used. Improvement was not so rapid as was expected, however. After several weeks, although there was no apparent postural defect, the effect of raising the inner edge of the shoe and supporting the arch (by a felt pad) was tried. Both at the time and afterward the patient was very definite in this statement that this "felt better," and improvement was so much more rapid after this that I feel certain it was a valuable adjunct in treatment.

Case VII is important, it seems to me, in suggesting the value of the more general use of temporary support (Thomas heel or felt pad) to the arch in the treatment of injuries of the knee, and since the measure is such a simple one, there is no good reason why it should not be employed.

Conclusions. 1. The production of symptoms at the knee by abnormal foot posture is easily explained by mechanical laws.

2. Pain in or around the knee may exist unassociated with pain in the foot.

3. Strain at the knee from abnormal foot posture may, if unrelieved, produce actual joint changes.

4. Such strain may also be a potent factor in keeping up disability of the knee-joint due primarily to other causes.

5. In all cases of primary knee-joint disease apparent defects of the foot should be corrected, and in resistant cases, especially old traumatisms, even when no apparent defect is present, the transference of the weight to the outer border of the foot is recommended.